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EFFECTS OF ENCUMBERING CLOTHING, PERSONAL-PROTECTIVE EQUIPMENT --ETC(U)
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UNCLASSIFIED AMRL-TR-76-118 NL

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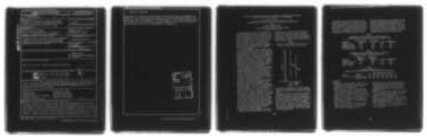

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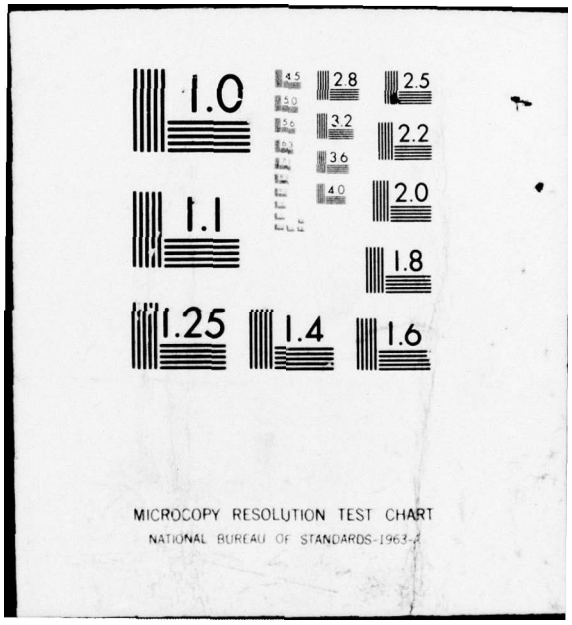
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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: AMRL-TR-76-118	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: EFFECTS OF ENCUMBERING CLOTHING, PERSONAL-PROTECTIVE EQUIPMENT AND RESTRAINTS ON BODY SIZE AND ARM-REACH CAPABILITY OF USAF AIRCREWMEN	5. TYPE OF REPORT & PERIOD COVERED: Preprint
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Milton Alexander, (AMRL); Lloyd L. Laubach, PhD (Webb Associates)*; John T. McConville (Webb Associates)*	8. CONTRACT OR GRANT NUMBER(s): In part under F33615-76-C-5007
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Aerospace Medical Research Laboratory, Aerospace Medical Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio 45433	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 62202F, 7184-12-03
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE: May 1976
	13. NUMBER OF PAGES: 4
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*	15. SECURITY CLASS. *(of this report)*: UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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18. SUPPLEMENTARY NOTES

*Joint effort with Webb Associates, Inc., Yellow Springs, OH 45378. Reprinted from Preprints of 1976 Scientific Program, Aerospace Medical Association and presented at the meeting held at the Americana Hotel, Bal Harbour, Florida, 10-13 May 1976.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Anthropometry	Workstation Design
Cockpit Layout	Arm Reach Capability
Personal Protective Equipment	Pressure Suit Growth
Restraint Systems	Body Size Variability
Ejection Escape Envelopes	

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Basic anthropometric dimensions provide engineers and designers with data on the range of body size variability that must be accommodated in the design and development of clothing, personal-protective equipment and workspaces. Designers of cockpits and similar workspaces must also be cognizant of the growth in body size associated with various configurations of clothing and personal-protective equipment and the effects of these assemblies on performance of the users. A study of a stratified sample of 32 USAF pilots wearing their operational →

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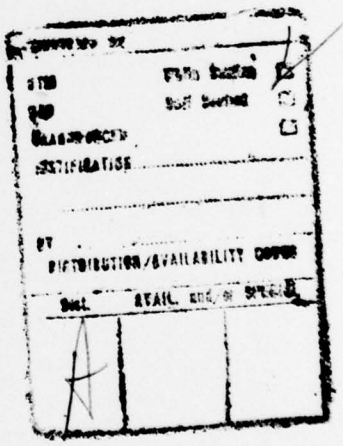
assemblages of over-land and over-water winter flight gear and equipment was conducted. The study determined changes in critical workspace dimensions and arm and leg reach performance due to encumberments of the clothing and equipment. The results of the investigation indicated changes occurred both in body size and performance which are of significance to designers.



EFFECTS OF ENCUMBERING CLOTHING, PERSONAL-PROTECTIVE EQUIPMENT AND RESTRAINTS ON BODY SIZE AND ARM-REACH CAPABILITY OF USAF AIRCREWMEN

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Basic anthropometric dimensions provide engineers and designers with data on the range of body size variability that must be accommodated in the design and development of clothing, personal-protective equipment and workspaces. Such data, both current and comprehensive, are readily available (White & Churchill, 1971; and Clauser, et al., 1972). Similarly, though somewhat less fully, workspace layout and reach capability base lines have been determined (Kennedy, 1964; Alexander and Clauser, 1965; Kennedy and Bates, 1965) for use by design engineers.

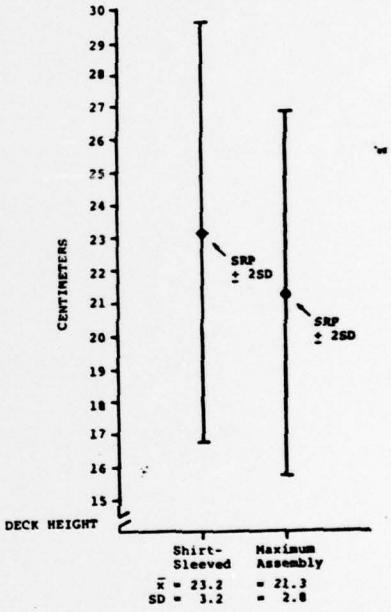
Far less comprehensive data are available, however, to describe the increases in body size associated with various configurations of clothing and personal-protective equipment and their effects on the performance of the operators. The increase in body size of a pilot, encumbered by multi-layer garments and restraints, is significant as is the decrease in his arm-reach capability. The purpose of this paper is to assemble and present results of selected studies aimed at providing design engineers with guidelines for dimensional modifications associated with encumbered pilots.

One such study (Laubach & Alexander, 1975) of a stratified sample of 32 USAF pilots wearing operational assemblages of winter flight gear and equipment was conducted to determine the increase in body size resulting from the heavy flight clothing. Table 1 depicts the growth factors in four body dimensions of pilots dressed in winter clothing. The parameters selected are relevant to the design of ejection envelopes.

The winter gear described above does not even represent the worst case of potential increase in body size of the Air Force crewmember. The largest recorded growth increment occurs in the full pressure suit. While not in widespread use by USAF crewmembers, such suits are currently used in special operations and in all probability should be considered in the design of many future weapons systems. A study (Alexander, et al., 1969) has been conducted to determine the increase in body size when wearing a pressure suit inflated to an operational pressure of 3.7 psi. Table 2 illustrates the increase in body size and clearances which occur when the operator is encased in a suit inflated to this extent. This study was conducted with the A/P22S-2 full pressure assembly. While it is recognized that each suit design will have its own inflational growth characteristics, Table 2 does illustrate the magnitude of growth in body size that must potentially be accommodated in workspace layouts.

Another factor to be considered in designing workspace for the encumbered operator is the eye reference point, a common cockpit design datum which can shift significantly when a maximum assemblage of clothing and personal-protective equipment are interfaced between the operator and his workstation. The magnitude of this change is demonstrated by the shift in seat reference point (SRP) as shown in Figure 1.

FIGURE 1.
Adjustment in Seat Reference Point Due to the Effects of Personal-Protective Clothing



This shift in eye point can be readily accommodated by seat adjustment but it does change what is normally believed to be the neutral SRP design datum.

Arm-reach capability is significantly hampered by protective flight clothing and little data exist for the guidance of aircraft designers who must add and subtract estimated increments for suited, helmeted and harnessed pilots. Results of two such investigations (Laubach & Alexander, 1975; and Garrett, et al., 1970) are presented below. Table 3 summarizes the results of two separate studies in which arm-reach was tested at selected angles throughout a 180-degree envelope on subjects dressed both in winter clothing and in full pressure suits.

The studies cited in this paper can, at best, only serve as guidelines for designers, since the continuous introduction of new items of clothing, revised assemblages of personal-protective equipment and new types of restraint systems make new data mandatory. The data presented here do, however, call to the attention of cockpit designers the necessity of evaluating the effects these encumbrances have on both the size and the biomechanical capability of the aircrewman. Consideration of these factors is absolutely vital not only when new equipment and designs are introduced into Air Force weapon systems but also, it should be emphasized, at an earlier stage. When new clothing or equipment is desired, the design process should include an assessment of the effect of changes in the new gear on the size and performance capabilities of the ultimate users.

TABLE 1

INCREMENTAL AND PERCENTAGE GROWTH CHANGES IN BODY SIZE
DUE TO THE EFFECTS OF PROTECTIVE CLOTHING AND EQUIPMENT (n=32)

Dimension	Winter Clothing 95%ile (cm)	Shirt-Sleeved 95%ile (cm)	Δ (cm)	% Difference
Shoulder Breadth	57.8	53.0	4.8	8.3
Forearm-Forearm Br	76.5	61.1	15.4	25.2
Thigh-to-Thigh Br	58.4	51.1	7.3	14.2
Normal Knee Spread	67.3	55.6	11.7	21.0

TABLE 2

INCREMENTAL AND PERCENTAGE GROWTH CHANGES IN BODY SIZE
DUE TO THE EFFECTS OF PRESSURE SUITS (n=34)

Dimension	Pressure Suit Inflated 95%ile (cm)	Pressure Suit Uninflated 95%ile (cm)	Δ (cm)	% Difference
Forearm-Forearm Br	73.9	59.5	14.4	24.2
Thigh-to-Thigh Br	51.0	41.1	9.9	24.1
Knee-to-Knee Br	51.1	29.7	21.4	72.1

TABLE 3

A SELECTED SUMMARY TABLE
PERTAINING TO ARM-REACH CAPABILITY OF USAF AIRCREWMEN (5%ile Values)

Level	Condition	Percent of Base Line Condition R90°	L90°	R60°	L60°	R30°	L30°	0°
61 cm Above Deck	Winter Clothing	88%	91%	87%	86%	82%	82%	75%
	Pressure Suited	83%	82%	78%	78%	75%	63%	72%

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